TURBINE UNIT AND VTG MECHANISM THEREFOR

TECHNICAL FIELD

[0001] The present invention relates to a turbine unit - in particular, a turbocharger, as well as for other types of fluid flow machines, such as secondary air pumps - comprising a turbine rotor housing having at least one admission channel for a fluid - in the case of an employment of the invention for a turbocharger this will be the exhaust gas of a combustion engine - and a turbine rotor, which is housed in a turbine space of the rotor housing and said fluid is led to the periphery of the turbine rotor through a variable geometry mechanism. The variable geometry mechanism comprises a nozzle ring having a plurality of nozzle shafts which are arranged in the nozzle ring in the form of a crown, and wherein each shaft has nozzle vanes fixed to one of its ends, said nozzle vanes being capable of being adjusted from a substantially tangential position into an approximately radial position (as seen with reference to the crown of vane shafts) as well as at least one adjusting element for adjustment of the position of the vanes. Moreover an actuation mechanism is provided in order to convey regulated movements to the variable geometry mechanism by means of a control ring, which is provided coaxially to the nozzle ring and adjacent thereto, and which is connected with at least one control element, as well as a guiding and centering mechanism for the control ring, having at least one roller bearing which comprises cylinders which roll on a contact surface of the control ring.

BACKGROUND OF THE INVENTION

[0002] A turbine unit of this type has been disclosed in US-A-4,179,247. This document emphasizes correctly without doubt, that high precision of guiding and centering can be obtained with a roller bearing, it being understood, however, the document

discloses a ball bearing. Although this document is older than twenty years already, it has had no impact on any practical application. The reason is probably that the turbine housing - in order to house the roller bearing - has such a complicated shape that it could not be reasonably fabricated. In addition the necessary surface treatments on portions which are not easily accessible, would have additionally increased fabrication cost. The measures which are taken in order to allow access to parts which possibly need repair, weaken the housing, and result in an unacceptable lack of operational security. This disclosure - in spite of the likely advantages of a roller bearing - was not sufficiently matured and therefore not suitable for practical application.

[0003] It was already known to locate the control elements on the vane shafts at their ends opposite to the nozzle ring, and whereby control levers were used with each extending approximately radially and which comprised one free end. It is additionally known from DE-C-954,551, to provide the control ring with teeth in which a pinion may engage. Other control mechanisms have been proposed which use the effect of inter-engaging teeth. Also the use of cams in form of slots is known in order to pivot the vanes around their shafts.

SUMMARY OF INVENTION

[0004] The invention has the objective to create a simple and easy to assemble construction of a VTG mechanism while using (at least) one roller bearing that maintains said advantages.

[0005] According to the invention this objective is obtained in a VTG mechanism wherein the roller bearing is arranged between the control ring and a fastening ring which is releasably connected with the rotor housing, so that the control ring, roller bearing and the releasably connected ring may be mounted into the rotor housing as one modular unit.

[0006] In this way not only is the mounting facilitated, but the rotor housing can also be simplified and thereby will be more stable. The precision which is inherent to a roller bearing is also maintained therewith. In addition this permits the prefabrication of the unit along with the vanes and spacers etc. so that the unit may constitute a proper commerciable object.

[0007] In the same way as in US-A-4 179 247, the roller bearing may also be a ball bearing, such as will be apparent from the following description. It is, however, preferred that the roller bearing is a cylinder bearing.

[0008] In order to create a cage, i.e. a means for holding together the rollers of a roller bearing, it is of advantage, that the roller bearing is housed in an axially open free space of one of the rings, preferably of the control ring, and this free space is closed by another ring, which can house axial extensions of the rollers of the roller bearing. In this way the friction of the rollers among each other and their number may be decreased if the rollers can be held a certain distance from one another by said holding ring. The roller bearing may therefore comprise cylinders or balls, which are either present in a sufficient number in order to substantially fill the free space, or it can have a limited number of at least three cylinders or balls which are guided by a holding ring in said free space.

[0009] Cost and the necessary space for the mounting of the modular unit may further be decreased if the function of the releasably connected ring is assumed by the nozzle ring itself.

[0010] A problem in turbochargers is the enormous heat which results in important thermal dilatations. An approach has been made already in different guiding mechanisms, to design them in a way that the rotational bodies may run either on an exterior or an interior track (see US-A-4 659 295). The

present invention, however, is based on the finding that the control ring and the nozzle ring may have been pre-centered previously by means of the control levers which extend between them. Therefore, it is preferred in this invention that the plurality of control elements is arranged on the side of the nozzle ring opposite the vanes and which are constituted by adjustment levers which are fastened to free ends of the vane shafts and extending radially, having one free end each. The guiding and centering mechanisms then only need to secure their coaxial position. Of course a like pre-centering will be obtained also if each control element is formed by a pinion which engages into a toothed crown.

[0011] Under these circumstances it is not absolutely necessary that the roller bodies are in constant abutment with at least one rolling track, it can be more advantageous if the diameters of the control ring and of the releasably connected ring which cooperate with the roller bearing, are dimensioned such as to substantially produce a radial play of the roller bodies. This play will then correspond to the admitted tolerances. "Substantially" means that in the region of the upper respectively lower threshold temperature or within the tolerances, this play may be 0 and the roller bodies will then abut on the one or the other ring. The design according to the invention not only secures a problem-free control movement within all temperature regions, but moreover increases the lifetime of the roller bearing.

[0012] Without any doubt it is possible in the framework of the present invention, to fasten the modular unit within the housing by means of screws. It is, however, preferred when the modular unit, comprised of the control ring, the roller bearing and the releasably connected ring (the unit will generally also include additional elements such as spacers and fastening elements), is maintained in non-rotatable condition through inter-engaging projections and depressions, and

preferably is solicited into this position through a soliciting device. This will make assembly much simpler. Alternatively one could provide a snap connection between the projections and depressions instead of a soliciting device.

[0013] Of course roller bearings are vulnerable to soiling and it is therefore advantageous to provide a ring shaped sealing between the turbine space and the roller bearing.

[0014] In the framework of the present invention it would be possible to provide the roller bodies between an external surface of the control ring and the internal surface of a ring surrounding the latter and being releasably connectable with the housing. This, however, increases the radial space requirement, and it is therefore preferred that the rolling contact surface of the releasably connected ring have a smaller diameter than the rolling contact surface of the control ring.

[0015] The present invention also relates to a VTG mechanism of turbine units as discussed hereinabove, which comprises the above discussed features.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Further details of the invention will be apparent on the basis of the following description of embodiments, illustrated in the schematic drawings.

Fig. 1 shows a half axial cut through a rotor housing, in which a VTG mechanism according to the present invention, is mounted;

Fig. 1a is an alternative embodiment for a VTG mechanism which may also be preassembled;

Fig. 2 is a cut representation of a VTG mechanism according to Figure 1;

Fig. 3 is a variation of the embodiment according to Figure 2 including a sealing, whereby only the upper portion of Figure 2 is illustrated in enlarged scale;

Fig. 4 is a cut perspective view from the side of the control ring;

Fig. 5 is a perspective partial view of a further embodiment, and

Fig. 6 is a cut through the upper side of a fourth embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0017] According to Figure 1 a turbine housing 2 is connected with a flange 16 of the bearing housing, from which a cylindrical member 40 extends into the turbine housing 2 and carries shaft 45 of a turbine rotor 4. The turbine housing 2 comprises an admission channel 9 which surrounds a turbine rotor 4, guiding a fluid which drives turbine rotor 4 (in the case of a turbocharger this fluid is an exhaust gas of a combustion engine), a rotor space 23 and an axial cylinder 10 through which the fluid, respectively the exhaust gas, will be discharged.

[0018] In order to lead fluid to turbine rotor 4 in regulated or controlled manner, a device is provided at the exit of an admission channel 9 before rotor space 23, which is known in the art as VTG (variable turbine geometry) mechanism. This VTG mechanism comprises in principle a crown of movable vanes 7 concentrically surrounding turbine rotor 4 (see figure 4), which are carried by control shafts 8 which are firmly connected thereto, and which are located in a nozzle ring 6 which coaxially surrounds turbine rotor 4.

[0019] The rotation of the control shafts 8 may be effectuated in known manner as shown e.g. in US-A-4 659 295, which shows an actuation device that comprises a control box 12, that controls the control movement of a pusher which is indicated in dash-dotted line, whose movement is transformed, through an actuation lever 13, an actuation shaft 14 which is connected therewith, and an eccentric 15 which engages into a hole of control ring 5 that is located next to the nozzle ring 6, into a small rotational movement of ring 5 around axis ®. The free ends or heads 18 of the control levers 19 are located in excavations 17 (see figure 4) of control ring 5, whereby the other ends of the control levers are fastened on the control shaft 8. Instead of excavations 17 which go all the way through in radial direction, one can also provide, in known manner, grooves on the radial inner side of the control ring 5 in which heads 18 are located, so that said heads 18 assure a certain pre-centering. As one will see from the following description, in the solution according to the invention, it is not necessary that this be the case, so that control ring 5 may have, other than in the state of the art, an even smaller diameter.

[0020] Through the said rotational movement, vanes 7 may be reoriented by shafts 8 relative to the turbine rotor such that they may rotate from an approximately tangential extreme position into an approximately radially extending opposite extreme position. Consequently more or less exhaust gas is led through the admission channel of a combustion engine on the turbine rotor 4 whereafter it is discharged along rotational axis R through axial cylindrical portion 10.

[0021] This mechanism as described hereinabove is principally known. However, in the state of the art, means were used for the guiding and the centering of control ring 5 relatively to nozzle ring 6, which were fastened to the housing 2, which are difficult to mount and which nevertheless

permitted only relatively small precision. As mentioned above there has been made already an approach to use roller bearings, but it was not feasible in practice because the roller bearing was to be mounted onto surfaces which needed precise treatment, whereas the rotor housing was subjected additionally to largely variable temperatures. In order to nevertheless obtain high precision with minimum constructional effort and minimum mounting effort, the roller bearing with its roller bodies 3 in the shape of cylindrical rollers, is located between control ring 5 and a bearing ring which is releasably connected to the rotor housing. The separation already of the releasable connected ring, serving as rolling contact surface, from the proper rotor housing protects said ring from an immediate heat transfer from housing 2 to itself. Additionally it is possible to mount control ring, roller bearing and realeasably connected ring (together with the above mentioned additional elements) as a modular unit into the rotor housing, i.e. it enables premounting, which may of course be carried out much easier and automized.

[0022] As can be seen from figures 1 and 2, control ring 5 comprises a rolling contact surface 20 which is oriented inwardly, and on which rollers 3 may roll. This is, however, only preferred in terms of tolerance compensation, because in practice it is preferred when rollers 3 maintain a certain play p (figure 2) in all operational phases between themselves and rolling contact surface 20 as well as between themselves and an opposing external contact surface 21, which forms a shoulder on nozzle ring 6.

[0023] As it has been explained already with respect to Figure 4, only a small number of rollers 3 are required, if a cage for holding ring 22 is provided. Rollers 3 may run within holes of appropriate size, corresponding to the rollers, in the holding ring 22, rollers 3 may advantageously comprise axial extension 24 of smaller diameter, which engage into

holes 25 in the rolling ring 22, so that the latter provides the necessary distance between rollers 3 in peripheral direction as well as it holds them firmly on and against rolling contact surfaces 20 and/or 21. Referring to figure 6 further down, it will be explained that a like holding ring, more in the sense of a cage ring, may be used also for roller bearings with balls as roller bodies, which balls 3 are held by this ring in certain distances from each other along the periphery of the rolling contact surfaces, whereby the cage ring comprises depressions which correspond to the balls. For balls 3' (figure 6) this distance is less critical, because even if they are tightly arranged one next to the other, they will only have temporary contact between them, whereas with tightly packed rollers 3, linear contacts are produced, which would result in increased friction. Therefore the roller ring 22 is of special advantage for the use of rollers as rolling bodies, especially as under the high rotational speeds of turbochargers, this friction can play a non-negligible role.

[0024] As shown in figure 1, it is possible, to provide the modular unit or cartridge which is comprised of control ring 5, nozzle ring 6 and all the other, therewith connected elements, additionally with a fastening ring 29, which may either be screwed onto a wall 2' of turbine housing 2 or as shown, can be screwed by means of bolts 30 and with the use of spacers 30a to nozzle ring 6.

[0025] It may also have a soliciting device such as a plate spring 32, which abuts on an inner flange 6' of nozzle ring 6 in order to immobilize it in axial direction and to press it against wall 2'. The other radial end of plate spring 32 abuts on a cylinder portion 40 of the bearing housing. In this case it is useful to bear the fastening ring by means of pins 24a in the turbine housing in non-rotational, but axially movable manner.

[0026] As alternative hereto, and in order to hinder the rotation of nozzle ring 6, nozzle ring 6 can be provided with projections on its rim, which insert into corresponding depressions in the housing wall 2a (or of the ring 2c) or the projections may be provided on the housing and extend into the depressions of the nozzle ring, such as illustrated by line 33. Alternatively one of the two elements to be connected to each other may comprise axial projections, such as pins which reach into axial depressions such as holes. Of course there is another traditional possibility, to firmly screw nozzle ring 6 to a ring corresponding to shoulder 2c of the rotor housing 2.

[0027] If a plate spring 32 is used as the soliciting device in order to obtain a firm positioning of unit 26 (see figure 2) in housing 2, one has to be aware that if one wants to use the preferred design for a turbocharger as described hereinabove, that such a plate spring 32 will be subjected to enormous thermal stress, which could reach from freezing temperature in winter during shut down of the engine up to almost 1000°C. This will of course have a certain impact on the metallic structure of the plate spring 32, another reason why other soliciting devices or soliciting means may generally be preferred. Thus, it is possible to provide gas springs around the periphery of modular unit 26, i.e. pistons which slide within cylinders which, when filled with air and which have a return valve, whereby the piston rods are pressed against nozzle ring 6. The air could be taken from the compressor space (of the non-illustrated compressor which is arranged on rotation axis R). Although a pressure charging device is preferred, a device which creates a drawing force is also imaginable.

[0028] In figure 1 an alternative solution is illustrated for the VTG mechanism which can be pre-assembled in cartridge form. Here the rolling bodies 3' are not supported between control ring 5' and nozzle ring 6', but between control ring 5

and a further ring 38, which is releasably connectable with a portion of the housing, and said rolling bodies 3' are arranged on the side of the control ring 5' which is opposite to the nozzle ring 6'. The fixation of the cartridge may be carried out through a solidarization of ring 38 with nozzle ring 6' (not illustrated) such as through screwing or welding from radially inner of portions 6'' and 38'' of these two rings 6' and 38 which practically abut on one another.

[0029] The embodiment illustrated in figure 5 uses this alternative solution.

[0030] The modular unit 26 of figure 1, as illustrated in figure 2, comprises the holding ring 22, located preferably between a radial flange 6' of the nozzle ring 6 and a radial flange 5' of control ring 5 which extends inwardly, and which thus delimits an axial open free space 5'', in which rolling bodies 3 are located. It is understandable that the cooperation of control ring 5 and of nozzle ring 6 (which is the further ring in the present embodiment) may also be designed reversely, inasmuch as control ring 5 may possess a radial flange 6' and nozzle ring 6 may have an axially open free space 5''. Actually its contact surface 21 forms, together with radial flange 6' such an axially open free space 21, 6'. Figure 2 further illustrates that control shafts 8 may have a decreased diameter at their ends corresponding to vanes 7, which may be press fitted into borings of vanes 7.

[0031] Figure 3 illustrates a slightly modified unit 26a in a similar cut as in figure 2. The modification with respect to figure 2 concerns the use of a seal ring 27 within a seal groove 28 of nozzle ring 6. As shown from a comparison with figure 1, nozzle ring 6 is located in the region of housing wall 2a. One could think of different types of sealing arrangements: either sealing ring 26 is designed as a flexible sealing lip, which fits from below against wall 2a. This is in principle problem free, because these two parts do

not move relatively to each other during operation. It is, however, also possible (or additionally employable) that sealing ring 27 may reach into a groove of wall 2a and thus forms a kind of labyrinth sealing, as well as combinations of both possibilities can be used. With the use of this type of sealing, one may inhibit soiling of roller bearing 3, 20, 21 coming from the area of the admission channel.

[0032] A further modification of unit 26a with respect to unit 26 is that it comprises a fastening ring 29 which protects vanes 7 in a defined distance (see figure 1), which ring 29 may be fastened to roll 2'. It may however also be fastened to the nozzle ring 6 by means of bolts 30, whereby, in known manner, spacers 31 provide a slightly larger distance as the width of the vanes 7, in order to provide free movement of vanes 7 in all temperature ranges.

[0033] Although, as already discussed hereinabove, with reference to figure 4, the two compared units 26 and 26a are not different as to the design of the roller bearings, it will now become clear in comparison with figure 3, that figure 4 is illustrating a different embodiment than figure 3, since it shows holding ring 29 as well as sealing ring 27.

[0034] The embodiment according to figure 5, however, is different from the hereto described variations inasmuch, as the chain of parts in axial direction has been reversed. Although this possibility is discussed here only with reference to one single example, it should be clear that combinations of the above described modifications and variations are within the spirit of the present invention.

[0035] According to the embodiment of figure 5, control levers 19 are not positioned on the side of control ring 5 which is opposite to nozzle ring 6, such as illustrated, but between those two rings 5, 6. Control ring 5 may be designed such as illustrated in figure 4, it may however also comprise pins 36 which reach into long holes 37. While control ring 5

again comprises a rolling contact surface 20 for rolling bodies 3 which is radially inwardly oriented, the other, opposite rolling contact surface 21' is formed by a separate ring 37, which is housed within control ring 5 and its running contact surface 20. In axial direction then follows again holding ring 22. In order to immobilize movable holding ring 22 in axial direction an end ring 39 may be present which would be firmly connected to ring 38, such as for example through screws and spacers which are arranged around said screws, and which extend through holding ring 22. Substantially this end ring plays a similar role as the fastening ring of figures 3 and 4 on the other side, inasmuch as it assures the holding together of the modular unit, and it may be connected with the housing 2 in one of the described fashions.

[0036] Hereinabove reference has been made already to figure 6. It needs to be said, however, that the arrangement in figure 6 is similar as in the case of the embodiments according to figure 1 to 4. This means that roller bearing 3', 20', 21' between control ring 5 and nozzle ring 6, is preferred. However it has to be emphasized again, that also in this case an arrangement according to figure 5 could be chosen in which the rolling bodies roll on a separate roller ring 37. It is also visible, that here rolling contact surfaces 20', 21' comprise depressions to receive balls 3', so that a specific cage ring (according to holding ring 22) is not necessary, although there may be space for it. If one wishes instead of the depressed surfaces 22', 21' to use cylindrical surfaces, it would certainly be necessary to use rollers 3 (see the previous examples) or one could use a cage ring according to the above discussed embodiment within a slot 22'. Further one can see in figure 6 that a sealing groove 26 is provided in which can be inserted either a sealing ring 27 (figure 3, 4) or a sealing ring which is located in the

housing, and which can be formed as a piston ring in order to form a labyrinth sealing.

[0037] As already mentioned, it is within the framework of the present invention that all characteristics which have been described with reference to a particular embodiment can be combined with themselves as well as with characteristics known from the state of the art. It has been mentioned that the embodiment according to the invention may preferably be employed for turbochargers, as it has been optimally conceived for operation parameters of such turbochargers. It is, however, also imaginable to employ the invention for operation with other types of fluids. Further it is understandable that the rotor housing may comprise several turbine rotors 4 and/or several admission channels 9 such as it has already been proposed in the state of the art. In the case of several rotors 4 one can provide several VTG mechanisms 26, 26', which may be the same or different, so that for instance one VTG mechanism corresponds to one of the described embodiments and another one to another embodiment.

List of reference numbers

2	rotor housing
2a	wall of 2
2'	wall of 2
3	roller body (rollers)
3'	balls
4	turbine rotor
5	control ring with radial flange 5'
6	nozzle ring with flange 6'
7	vane
8	control shaft
9	admission chanel
10	axial rod
11	actuation device
12	control box
13	actuation lever
14	actuation shaft
15	excentric
16	flange
17	excavation
18	head respectively end of lever of 19
19	control lever
20	rolling contact surface of 5
21	roller contact surface of 6
21'	roller contact surface of 6
22	cage or holding ring (in 22')
23	rotor space
24	axial extension
25	holes of 22
26	modular unit
27	sealing ring
28	sealing groove

29 fastening ring
30 bolt
31 spacer
32 plate spring
33 teeth
35 rotor shaft
36 pin
37 long hole
38 roller ring
39 endring
40 cylinder portion